In the Claims

    This listing of claims will replace all prior versions and listings of claims in the application:

1 1. (Currently Amended) A method for generating digital filter
2 coefficients for corresponding digital filters for tuning a hearing
3 aid employing digital audio processing to enhance hearing ability
4 comprising:
5   providing first digital data for a tolerance range for a
6 target response curve representative of said enhanced hearing
7 ability of sound level versus frequency;
8   providing second digital data representing an initial response
9 curve of an initial hearing ability to be enhanced of sound level
10 versus frequency;
11   comparing said first digital data to said second digital data
12 and determining whether said initial response curve is within said
13 tolerance range; and
14   if said initial response curve is not within said tolerance
15 range, iteratively generating digital filter coefficients
16 controlling center frequency, filter bandwidth and amplitude for a
17 succession of _additional_ digital audio filters, applying all
18 currently generated digital audio filters to said second digital
19 data to generate third digital data for a compensated response
20 curve, and automatically optimizing the center frequency, amplitude
21 and filter bandwidth of said currently generated digital audio
22 filters until said compensated response curve is within said
23 tolerance range or a predetermined limit on the number of digital
24 audio filters has been reached, whichever occurs first.

1 2. (Original) A method according to Claim 1, wherein said step of
2 iteratively generating digital audio filters is performed by
3 iteratively generating second order filters.

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1 3. (Original) The method of Claim 1 wherein said initial response
2 curve is an audiogram.

1 4. (Currently Amended) A method for generating a set of second
2 order filter coefficients for corresponding digital filters to tune
3 a hearing aid employing digital audio processing to enhance hearing
4 ability comprising:
5 providing first digital data for a tolerance range for a
6 target response curve representative of said enhanced hearing
7 ability of sound level versus frequency;
8 providing second digital data representative of an initial
9 response curve of an initial hearing ability to be enhanced of
10 sound level versus frequency;
11 comparing said first digital data to said second digital data
12 and determining whether said initial response curve is within said
13 tolerance range; and
14 if said initial response curve is not within said tolerance
15 range, generating a set of digital filter coefficients controlling
16 center frequency, filter bandwidth and amplitude for a succession
17 of additional digital audio filters to tune said hearing aid by
18 performing the following optimizing steps iteratively,
19 digitally processing said second digital data to
20 determine an nth set of initial digital filter coefficients for
21 an nth digital filter for an nth peak in said actual initial
22 curve where said initial response curve is not within said
23 tolerance range, including a center frequency, and an
24 amplitude and a bandwidth for said peak, where n is the number
25 of an iteration of said optimizing steps,
26 digitally generating digital filter coefficients
27 controlling center frequency, filter bandwidth and amplitude
28 for a compensating nth digital filter from said n^{th} set of

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29   initial parameters,

30   applying said n^{th} digital filter to said second digital

31   data and modifying said n^{th} set of initial digital filter

32   coefficients to determine an nth set of optimum parameters for

33   said compensating n^{th} digital filter, to generate third digital

34   data for an nth interim compensated response curve of sound

35   level versus frequency,

36   processing said third digital data to determine whether

37   said nth interim compensated response curve is within said

38   tolerance range,

39   if said nth interim compensated response curve is not

40   within said tolerance range, performing another iteration of

41   said optimizing steps until said interim compensated response

42   curve is within said tolerance range or a predetermined limit

43   on the number of digital filters has been reached, whichever

44   occurs first.

1   5.   (Previously Amended) A method of Claim 4, wherein said step of

2   digitally generating a compensating nth digital filter is performed

3   by digitally generating a second order filter.

1   6.   (Original) The method of Claim 4, wherein said initial

2   response curve is an audiogram.

1   7.   (Currently Amended) A method for generating digital filter

2   coefficients for corresponding digital filters for tuning a hearing

3   aid employing digital audio processing to enhance hearing ability

4   comprising:

5   providing first digital data for a tolerance range for a

6   target response curve representative of said enhanced hearing

7   ability of sound level versus frequency;

8   providing second digital data for an initial response curve of

9   said hearing ability to be enhanced of sound level versus

10   frequency;

11   comparing said first digital data to said second digital data

12   and determining whether said initial response curve is within said

13   tolerance range; and

14   if said initial response curve is not within said tolerance

15   range, generating a set digital filter coefficients controlling

16   center frequency, filter bandwidth and amplitude for a succession

17   of additional compensating digital audio filters by performing the

18   following single filter optimizing steps iteratively,

19   digitally processing said second digital data to

20   determine an nth set of initial parameters for an nth peak in

21   said initial response curve where said initial response curve

22   is not within said tolerance range, including a center

23   frequency, an amplitude and a bandwidth for said peak, where n

24   is the number of an iteration of said optimizing steps,

25   digitally generating a compensating n^{th} digital filter

26   from said n^{th} set of initial parameters,

27   applying said n^{th} digital filter to said second digital

28   data and modifying said n^{th} set of initial filter coefficients

29   to determine an nth set of optimum parameters for said n^{th}

30   digital filter, to generate third digital data for an nth

31   interim compensated response curve of sound level versus

32   frequency;

33   if n > 1, performing the following joint filter optimizing

34   steps iteratively and cyclically,

35   generating fourth digital data for interim computed

36   response curves in which for each joint filter optimizing

37   iteration one of said n filters is absent, and then performing

38   said single filter optimization steps utilizing said fourth

39   digital data to generate fifth digital data for an updated

40   interim response curve,

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41   digitally processing said fifth digital data to determine

42   whether the most recent of said joint filter optimizing

43   iterations has resulted in a change in said updated interim

44   response curve greater than a predetermined amount of change,

45   and if so continuing to perform said joint filter optimizing

46   steps;

47   processing said fifth digital data to determine whether

48   said n^{th} interim compensated response curve is within said

49   tolerance range, and if not,

50   performing another iteration of the foregoing steps

51   until said interim compensated response curve is within

52   said tolerance range or a predetermined limit on the

53   number of digital filters has been reached, whichever

54   occurs first,

55   but if so, ceasing performance of further iterations.

1   8.   (Previously Amended) A method according to Claim 7, wherein

2   said step of digitally generating a compensating n^{th} digital filter

3   is performed by digitally generating a second-order filter.

1   9.   (Original) The method of Claim 8 wherein said initial response

2   curve is an audiogram.

1   10.   (Previously Amended) A method for generating digital filter

2   coefficients for tuning a hearing aid employing digital audio

3   processing to enhance hearing ability of an individual comprising:

4   fitting said hearing aid to said individual;

5   connecting said hearing aid to a source of audio digital

6   signals;

7   providing said individual with a device to generate indication

8   signals at will;

9   generating and providing a first series of audio digital

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10 signals to said hearing aid, each digital signal in said first
11 series of signals corresponding to an analog audio signal having a
12 selected frequency and multiple power levels;

13   at said hearing aid converting each of said series of digital
14 signals into said corresponding analog audio signal;

15   receiving said indication signal during said generation of a
16 signal of a selected frequency indicative of said individual
17 hearing said selected frequency;

18   providing a digital audio processing unit in said hearing aid
19 for processing received audio digital signals corresponding to
20 analog audio signals and providing processed audio digital data,
21 including applying digital audio filters for tuning said hearing
22 aid characterized by generating digital filter coefficients in
23 algorithms applied to said received audio digital signals to effect
24 said digital audio filters;

25   providing a digital computer connected to receive said first
26 series of audio digital signals and said indication signals to
27 generate digital data representative of said individual's hearing
28 ability using said hearing aid without filters determined from said
29 first series of digital signals, said computer programmed to
30 determine said digital filter coefficients for digital filters for
31 tuning said hearing aid and providing said coefficients to said
32 digital audio processing unit in said hearing aid.

1 11.$^{\vee}$ (Currently Amended) A method according to Claim 10, wherein
2 said digital computer is programmed to determine said digital
3 filter coefficients by

4   providing second digital data for a tolerance range for a
5 target response curve ability of representative of said
6 individual's enhanced hearing ability of sound level versus
7 frequency;

8   providing first digital data representative of an initial

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9 response curve of said individual's hearing ability of sound level
10 versus frequency;
11   comparing said second digital data to said first digital data
12 and determining whether said response curve is within said
13 tolerance range; and
14   if said response curve is not within said tolerance range,
15   iteratively generating digital filter coefficients
16   controlling center frequency, filter bandwidth and amplitude
17   for a succession of <u>additional</u> digital audio filters,
18   applying digital audio filters determined by said digital
19   filter coefficients to said first digital data to generate
20   third digital data for a compensated response curve, and
21   automatically optimizing said digital filter coefficients
22   by optimizing the center frequency, amplitude and filter
23   bandwidth of said digital audio filters until said compensated
24   response curve is within said tolerance range or a
25   predetermined limit on the number of digital audio filters has
26   been reached, whichever occurs first.

1 12. (Previously Amended) The method of Claim 11 wherein said
2 computer receives said first series of signals and indication
3 signals generated by said device to generate said first digital
4 data.

1 13. (Original) The method of Claim 11 wherein said first digital
2 data is an audiogram.

1 14. (Previously Amended) An apparatus for generating digital
2 filter coefficients for tuning a hearing aid digital audio
3 processing for use by an individual, comprising:
4   a source of first audio digital data corresponding to analog
5 audio signals having a selected frequency and multiple power

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6   levels;

7   a digital audio processing unit in said hearing aid for

8   processing said first audio digital data according to at least one

9   digital filter having digital filter coefficients controlling

10 filter center frequency, amplitude and filter bandwidth and

11 providing processed audio digital data, including applying digital

12 audio filters for tuning said hearing aid characterized by

13 coefficients in algorithms applied to said first audio digital data

14 to effect said digital audio filters;

15   a digital to analog converter receiving said processed digital

16 data from said digital audio processing unit and converting said

17 processed digital data into a corresponding analog audio signal;

18   a speaker receiving said analog audio signal from said digital

19 to analog converter and producing corresponding sound to the

20 individual;

21   a device for generating indication signals indicative of said

22 individual receiving said sound; and

23   a digital computer connected to receive said first audio

24 digital data and said indication signals, said digital computer

25 programmed to determine said digital filter coefficients for

26 digital filters for tuning said hearing aid and provide said

27 coefficients to said digital audio processing unit.

1 15.ᵛ (Currently Amended) An apparatus according to Claim 14,

2 wherein said digital computer is programmed to generate second

3 digital data representative of said individual hearing ability when

4 using said hearing aid without filters determined from said first

5 audio digital data and said indication signals and to determine

6 said coefficients by

7   providing third digital data for a tolerance range for a

8 target response curve of enhanced hearing of sound level versus

9 frequency;

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10   providing said second digital data, wherein said second
11 digital data represents an initial response curve of hearing
12 ability of sound level versus frequency;
13   comparing said third digital data to said second digital data
14 and determining whether said initial response curve is within said
15 tolerance range; and
16   if said initial response curve is not within said tolerance
17 range,
18   iteratively generating digital filter coefficients
19   controlling center frequency, filter bandwidth and amplitude
20   for a succession of <u>additional</u> digital audio filters,
21   applying digital audio filters determined by said digital
22   filter coefficients to said second digital data to generate
23   fourth digital data for a compensated response curve, and
24   automatically optimizing said digital filter coefficients
25   by optimizing the center frequency, amplitude and filter
26   bandwidth of said digital audio filters until said compensated
27   response curve is within said tolerance range or a
28   predetermined limit on the number of digital audio filters has
29   been reached, whichever occurs first.

1 16. ⱽ (Currently Amended) A method for generating digital filters
2 for tuning a hearing aid to enhance hearing ability, comprising:
3   providing first digital data for a tolerance range for a
4 target response curve representative of said enhanced hearing
5 ability of sound level versus frequency;
6   providing second digital data representing an initial response
7 curve of an initial hearing ability to be enhanced of sound level
8 versus frequency;
9   comparing said first digital data to said second digital data
10 and determining whether said initial response curve is within said
11 tolerance range; and

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12   if said initial response curve is not within said tolerance
13 range,

14   iteratively generating digital filter coefficients
15 controlling center frequency, filter bandwidth and amplitude
16 for a succession of <u>additional</u> digital audio filters to
17 compensate said initial response curve,

18   applying said digital audio filters to digital signals
19 representative of received sound to generate third digital
20 data, converting said third digital data to an analog signal
21 and providing said analog signal to a speaker in said hearing
22   aid,

23   generating fourth digital data representative of an
24 enhanced response curve of hearing ability of sound level
25 versus frequency;

26   comparing said first digital data to said fourth digital
27 data and determining whether said enhanced response curve is
28 within said tolerance range; and

29   automatically optimizing the center frequency, amplitude
30 and filter bandwidth of said digital audio filters until said
31 enhanced response curve is within said tolerance range or a
32 predetermined limit on the number of digital audio filters has
33 been reached, whichever occurs first.

1 17. (Original) A method according to Claim 16, wherein said step
2 of iteratively generating digital audio filters is performed by
3 iteratively generating second-order filters.

1 18. (Original) The method of Claim 16 wherein said initial
2 response curve is an audiogram.

1 19. (Original) The method of Claim 18 wherein said enhanced
2 response curve is an audiogram.

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1   20. (Original) A method for generating total log-integral metric
2   digital data for characterizing the perceived performance of a
3   hearing aid, comprising the steps of:
4   providing first digital data for N samples for a desired
5   response curve of acceptable hearing ability of sound level
6   versus frequency;
7   providing second digital data representing N samples for an
8   initial response curve of sound level versus frequency; and
9   generating total log-integral metric data according to the
10   formula:

$$M = \sum_{i=1}^{N-1} \log_{10}\left(\frac{f_{i+1}}{f_i}\right)\left[\frac{|S(f_i)_{dB} - D(f_i)_{dB}| + |S(F_{i+1})_{dB} - D(f_{i+1})_{dB}|}{2}\right]$$

11
12 where:
13   M is the total log-integral metric,
14   f is the frequency,
15   D is the first digital data,
16   S is the second digital data, and
17   N is the number of samples of first digital data and of second
18 digital data.

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